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EXPLOSIONS IN INDIANA COAL MINES, 1878 TO 1933

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BY

C. A. HERBERT

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By C. A. Herbert 2/

PURPOSE OF THIS REPORT

Coal-mine explosions in the United States during the past 10 years ranked third among the causes of coal-mine fatalities and constituted 16.1 percent of the total fatalities. In Indiana, however, during this same period the percentage of fatalities from this cause was much higher than the average percentage for the entire country.

It is only through knowledge of the factors that have led to these past explosions that intelligent steps may be taken to prevent similar occurrences in the future. Although information concerning many of the earlier explosions is lacking, an attempt has been made to tabulate the information available in the hope that it may be of assistance in calling attention to some of the principal causes of explosions in Indiana.

EXPLOSIONS IN INDIANA COAL MINES

The data for this study were obtained from the files and published reports of the Mine Inspection Department of Indiana and from information gathered by engineers of the United States Bureau of Mines following explosions in the State.

The first mining law of Indiana was enacted in 1879; as the first mine explosion of which there is record had occurred on November 21, 1878, this law probably was a result of it. Following enactment of the law a mine inspector was appointed but apparently made no report during his 3 years in office--at least his reports did not appear in the annual reports of the Department of Geology to which had been intrusted the enforcement of the law.

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The next explosion reported occurred in Sullivan County, in September 1893, with 3 killed and 6 injured. Although fatalities may have resulted from minor explosions and gas ignitions between 1878 and 1893, no record of them could be found.

The third explosion of record occurred in Gibson County on December 26, 1896 and resulted in 7 fatalities. The next 6 years appear to have been immune from fatalities from explosions from either black blasting powder or gas ignitions.

In 1902, 2 minor explosions from blow-out shots of black blasting powder resulted in 3 fatalities. From 1902 to 1928 explosions of more or less magnitude occurred each year, nearly all of which were caused by overcharged and poorly placed shots of black blasting powder in solid shooting mines.

Table 1 summarizes data available on explosions in Indiana from 1878-1933, inclusive; those in which there was marked violence and for which more or less complete data are available are listed as separate cases. Those in which there was little violence or for which few data are available, are listed under "Other cases". A distinction is made in this latter classification between gas ignitions and blown-out shots of black blasting powder.

Doubtless there was considerable violence in many of the explosions from blown-out shots of black blasting powder, but because in many of the mines where solid shooting is practiced little timbering is necessary on entries, slight damage was done other than the blowing out of wood stoppings in the entry crosscuts, and work could be resumed with little delay. The shooting was done by shot-firers after all other employees were out of the mine, and the fatalities were confined to the 1 or 2 shot-firers in the mine at the time of the explosion.

From 1878 to 1933, inclusive, there were 32 explosions in which 1 to 51 fatalities occurred and for which there are fairly complete data. Ten of these may be classed as major explosions in which 5 or more were killed. A total of 213 fatalities resulted from these 32 explosions, an average of nearly 7 per explosion.

In addition to the 32 cases mentioned, there were 52 gas ignitions in which 61 were killed and 96 minor explosions with 119 fatalities from blown-out shots of black blasting powder, a total of 393 fatalities.

Fatality Rates

Table 2 presents the gas and dust fatality rates per million tons of coal produced and per million man-hours of surface and underground work.

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TABLE 1. - Gas and dust explosions in bituminous mines of Indiana, 1878-1933

Case No.	Date	County	Type of mine	Tons per day	Average employed	Men in mine	Explosions: Type	Extent	Limited by	Cause of accumulation	Source of ignition	Other factors	Possible means of prevention at time	Other cases: Killed	Injured	Escaped uninjured	Ignitions of gas	Killed	Blown-out shots	Killed	Total yearly fatalities from explosions and ignitions	Year
1	1878 Nov.21	Sullivan	Shaft gassy	300	100	100	Gas	Limited	Amount of gas	Poor ventilation	Open lights	-	Closer inspection, better ventilation	8	-	-	-	-	-	-	8	1878
2	1893 Sept.5	do	do	500	100	100	do	do	Amount of gas and expansion	do	do	-	do	3	6	-	-	-	-	-	3	1893
3	1896 Dec.26	Gibson	do New mine	200	50	50	do	do	Amount of gas	Lack of ventilation	do	-	do	7	-	-	2	2	-	-	9	1896
*1902 1/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	3	1902
*1903	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	3	3	4	1903
*1904	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	1904
4	1905 Jan. 4	Gibson	Shaft gassy	200	50	50	Dust	Extensive	Expansion	-	Blown-out shot of black blasting powder	Solid shooting. Badly placed shots	Undercutting coal; better placement of shots	9	-	-	1	1	1	1	11	1905
5	1906 Dec. 5	Vigo	Shaft	1000	200	200	do	Limited	Expansion, inert material	-	do	Poorly placed shots. Shooting during shift	Better placement of shots; better supervision	14	7	-	1	1	1	2	4	1906
6	1907 Jan.14	Vermillion	do	1200	220	211	Powder and dust	Extensive	Expansion	-	Ignition of several kegs black blasting powder	Careless handling of powder	Greater care in handling and distributing powder	7	-	-	1	2	2	3	12	1907
7	1908 Jan. 8	Gibson	Shaft gassy	750	160	2	Dust	Extensive violent	-	-	Blown-out shot of black blasting powder	Shot some holes that had blown out the night before	Undercutting and greater care in placing shots	2	-	-	1	1	2	2	5	1908
8	1909 Mar.20	Vanderburgh	Shaft	150	60	53	do	Widespread	Expansion, inert material	-	do	Shooting on solid during shift	Undercutting coal; better supervision over shooting	6	-	17	-	-	1	1	7	1909
*1910	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3	6	1910
*1911	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	4	5	6	1911

1/ Years marked with an asterisk are those in which there were no major accidents, or in which there were no injuries.

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TABLE 1. - Gas and dust exolosions in bituminous mines of Indiana, 1878-1933--Continued

Case No.	Date	County	Type of mine	Tons per day	Average employed	Men in mine	Explosions: Type	Extent	Limited by	Cause of accumulation	Source of ignition	Other factors	Possible means of prevention at time	Killed	Injured	Escaped uninjured	Other cases: gas ignitions	Killed	Blown out shots	Killed	Total yearly fatalities	Total yearly fatalities from explosions and ignitions	Year
9	1912 Nov.16	Vermil-lion	Shaft	340	48	2	Dust	Wide-spread	Expan-sion	-	Blown-out shot black blasting powder	Solid shooting. Poorly placed shots	Undercutting coal; better super-vision	2	-	-	1	1	4	5	8		1912
10	1913 Feb. 7	Gibson	Shaft gassy	500	125	2	do	Limited	do	-	do	Solid shooting. Overcharged shots	Undercutting coal; Permissible ex-plosives	2	-	-	3	3	2	3	---	11	1913
11	1913 Mar.22	Sulli-van	Shaft	1200	300	300	Gas	do	Amount of gas	Fall of top. Poor ven-tilation	Open lights	Fire boss took men into sec-tion	Better supervision; better ventilation	3	7	290	-	-	-	-	---	3	1913
12	1913 Aug. 1	do	Shaft New mine	300	50	50	Dust	do	Expansion and moisture	-	Blown-out shot black blasting powder	Shooting with men in mine. Solid shoot-ing	Undercutting coal; permissible ex-plosives	4	6	-	-	-	-	-	---	4	1913
13	1913 Dec. 29	Knox	Shaft gassy	1500	350	8	Gas and dust	do	Expan-sion	-	Open lights	Gas ignited by fire boss	Better supervision; better ventilation	3	-	5	-	-	-	-	--- 21	3 Total	1913 1913
14	1914 Sept.21	do	do	2000	300	300	Gas	do	Amount of gas	Lack of ventila-tion	do	Room boss caused ig-nition	do	2	3	295	1	1	3	4	7		1914
15	1915 Feb. 26	Sulli-van	Shaft	1000	150	2	Dust	do	-	-	Blown-out shot	Solid shooting with black blasting powder	Undercutting coal; permissible ex-plosives	2	-	-	5	5	6	7	14		1915
16	1916 Dec. 19	Knox	Shaft gassy	2000	240	191	Gas and dust	do	Amount of gas and ex-pansion	Gas pushed out of old works onto entry by fall	Open lights	Fire caused by explosion. Mine sealed. Two explo-sions on 21st, 3 on 25th. No fatalities in second or third explo-sion	Closed lights, closer supervision over ventilation. sealing old works	4	22	165	2	2	4	5	11		1916
*1917	--	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	9	8	10	19		1917

TABLE 1. - Gas and dust exolosions in bituminous mines of Indiana, 1878-1933--Continued

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Case No.	Date	County	Type of mine	Tons per day	Average employed	Explosions			Other cases				Total yearly fatalities from explosions and ignitions	Year
						Other factors	Possible means of prevention at time	Killed	Injured	Escaped uninjured	Gas ignitions	Killed blown-out shots	Killed		
25	1923 Dec. 20	Vermilion	Shaft	1500	300	Gas pushed out onto entry by fall	Better supervision; closed lights	3	-	-	-	-	-	---- 3 / 22 Total	1920
26	1924 Jan. 2	Knox	Shaft Sassy	2000	300	Lighted gas at pipe in seal	Better constructed seal; closed lights; lock valve seal	3	-	-	-	-	-	---- 3	1920
27	1925 Feb. 20	Sullivan	do Van	500	106	Idle day, mine not examined	Improved ventilation; examination of mine before letting men enter	5	6	-	3	3	6 8	---- 16	1920
28	1925 Feb. 25	Knox	do	1600	100	Solid shooting with black blasting powder. Shot holes second time; blown tamping day before	Undercutting coal; permissible explosives; use of water at face	6	-	3	4	6	6 7	19	1919
29	1926 Dec. 9	Gibson	do	2000	325	do	Undercutting coal; permissible explosives; wetting workings at face	1	-	-	-	-	-	---- 1 / 12 Total	1918 1918
30	1931 Jan. 28	Sullivan Van	Shaft Sassy	1200	130	Solid shooting with black blasting powder	Undercutting coal; permissible explosives	1	-	-	3	4	5 6	---- 11	1918
	*1930	-	-	-	-										
	*1929	-	-	-	-										
	*1928	-	-	-	-										
	*1927	-	-	-	-										

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Gas and dust explosions in bituminous mines of Indiana, 1878-1933--Continued

Explosions										Other cases					
Men in m	Type	Extent	Limited by	Cause of accumulation	Source of ignition	Other factors	Possible means of prevention at time	Killed	Injured	Escaped uninjured	Gas ignitions	Killed	Blown-out shots	Killed	Total yearly fatalities from explosions and ignitions	Year
4	Dust	Limited	Expansion	-	Blown-out shot black blasting powder	Solid shooting. One rescuer killed, one rescuer injured	Undercutting coal; permissible explosives; rock-dusting	2	1	1	3	3	4	4	-9	1923
6	Gas and dust	do	Incombustible. and expansion	Lack of ventilation caving rooms	Lighting flame safety lamp	Idle day, boss went into caving section, lighted safety lamp	Permissible flame safety lamps	1	-	-	-	-	4	6	7	1924
06	do	Wide-spread	Expansion	Lack of ventilation. Caving, squeezing rooms	Open lights	Knew section was making gas	Closed lights; rock-dusting; better inspection and supervision	51	1	54	1	2	5	8	--- 61	1925
00	Gas	Limited	Amount of gas	Lack of ventilation, open door	do	Section not working. Company men laying track	Better supervision and inspection	1	1	-	-	-	-	-	--- 1	1925
															62 Total	1925
71	Gas and dust	Wide-spread	Expansion, and inert material	Caving of rooms	do	Too long period between inspection and starting time. Section known to be caving	Closed lights; rock-dusting; water at face	37	15	19	3	3	5	5	45	1926
-	-	-	-	-	-	-	-	-	-	-	2	2	1	1	3	1927
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1928
-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1929
-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	1930
23	Gas and dust	Limited	Expansion, and inert mater-	Cave-in abandoned rooms	Open lights	Holed thru into old room with gas at face from heavy fall of rock	Better ventilation; better supervision and inspection; closed lights; rock-dust-	28	4	91	-	-	-	-	28	1931

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TABLE 1. - Gas and dust explosions in bituminous mines of Indiana, 1878-1933--Concluded

Case no.	Date	County	Type of mine	Tons per day	Average employed	Men in mine	Explosions							Killed	Injured	Escaped uninjured	Other cases				Total yearly fatalities from explosions and ignitions	Year
							Type	Extent	Limited by	Cause of accumulation	Source of ignition	Other factors	Possible means of prevention at time				Gas ignitions	Killed	Blown-out shots	Killed		
31	1933 Feb. 8	Vigo	Shaft New mine	500	100	2	Dust	Limited	Expansion	-	Blown-out shot black blasting powder	Solid shooting, poorly placed, overcharged shots	Undercutting coal; permissible explosives, rock-dusting, water at face	1	-	-	-	-	-	-	---	1	1933
32	1933 Feb. 24	do	Shaft	800	150	2	do	do	Size of mine	-	do	Solid shooting, poorly placed, overcharged shots. Shot holes that had blown out the night before.	Permissible explosives; more care in placing rock-dust.	2	-	-	-	-	-	-	---	2	1933
														213			52	61	95	119	393	Total	1933

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Until 1900 most of the coal in Indiana was produced from comparatively shallow beds that gave off little methane. Although black blasting powder was used exclusively as an explosive it was not used with the utter disregard for safety customary in the so-called solid shooting mines from 1900-26. In 1920, 49 percent of the coal produced in the State was shot from the solid with black blasting powder; since then, however, there has been marked improvement in mining methods, with an increasing percentage of the output undercut by machine. In 1923, 41 percent of the production was shot from the solid; by 1926 this had been reduced to 24 percent, while in 1933 only 14 percent of the total output was produced by this method of blasting. This marked reduction is reflected in the decrease in fatalities from explosions in 1932 and 1933. The excessively high rate in 1931 was due to a disastrous explosion that caused 28 fatalities.

TABLE 2. - Gas and Dust Explosion Fatalities in Indiana Coal Mines, 1878-1933

Period	Fatalities per million		Percentage of explosion fatalities to total killed in Indiana coal mines
	Tons	Man-hours	
1878-1890	0.26	0.07	6.0 (approximate)
1891-1895	.17	.05	3.0 do
1896-1900	.35	.12	9.0
1901-05	.41	.15	11.0
1906-10	.47	.21	15.0
1911-15	.70	.35	23.0
1916-20	.63	.36	20.0
1921-25	.89	.60	29.0
1926-30	.55	.45	24.0
1931	1.96	1.81	49.0
1932	.07	.08	3.0
1933	.22	.23	11.0

Causes of Explosions in Indiana

Table 3 gives the causes of the 32 explosions listed in table 1 for which more or less complete data are available. It will be noted that 16, or 50 percent, were due to open lights; 15, or 46.9 percent, to blown-out shots of black blasting powder; and 1, or 3.1 percent, to explosives.

TABLE 3. - Causes of explosions in Indiana coal mines

Cause	Number of explosions	Percent
Open lights	16	50.0
Blown-out shots	15	46.9
Explosives	1	3.1
Total	32	100.0

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Open lights.- Of the 16 explosions with 163 fatalities charged to open lights, 2 were caused by ignition of gas by fire bosses with open lights, resulting in the death of 3 men, including the fire boss, in each case. One was caused by ignition of gas by a room boss with an open light, with 2 killed, including the room boss. A fourth resulted when a fire boss, who had entered the mine to examine a caving territory on an idle day, attempted to relight a disassembled flame safety lamp. Therefore 4, or 25 percent, of the explosions charged to open lights were caused by mine officials. One explosion charged to open lights was of uncertain origin, either having been caused by a mine fire or an open light; the latter, however, seemed to be the most probable cause.

In addition to the 16 explosions charged to open lights, there were 52 ignitions of gas by open lights, resulting in 61 fatalities. Of these 61 fatalities, 20 (38.5 percent) were of mine officials, as follows: superintendents, 2; mine bosses, 5; room bosses, 5; fire bosses, 8. In 5 of the ignitions in which officials were killed, the officials were responsible for the loss of 1 or more lives in addition to their own, as they led men wearing open lights into explosive mixtures of gas without first examining for gas.

Blown-out shots of black blasting powder.- The reckless use of black blasting powder was responsible for 15 (46.9 percent) of the 32 explosions listed in table 1, which resulted in 43 fatalities. One of these explosions, in which 6 men were killed, occurred while officials were attempting to get boiler coal while the mine was idle because of a strike. The coal was being shot from the solid with black blasting powder; shots fired the previous day had blown out and only cracked the coal, and these same shot holes were again loaded and fired, causing an explosion. A second and somewhat similar explosion caused the death of 2 night bosses who reloaded and fired 2 black-blasting-powder shots that had been improperly placed and had blown the tamping on the previous night.

In addition to the 15 explosions mentioned above, there were 96 minor explosions of more or less violence on which little data are available. These 96 minor explosions, listed in table 1 as "Other cases", resulted in 119 fatalities. A total of 162 miners, mostly shot-firers, lost their lives as a result of blown-out shots of black blasting powder; thus, 41 percent of the total loss of life by explosions and gas ignitions was due to reckless use of explosives.

Explosives.- Only 1 explosion was charged to explosives; this was due to the accidental ignition of several kegs of black blasting powder and caused 7 fatalities.

TABLE 4. - Types of explosions in Indiana mines

Condition	Gas	Dust	Gas and dust	Total
Nongassy	1	13	-	14
Gassy	9	3	6	18
Explosions	10	16	6	32
Fatalities	39	50	124	213

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TABLE 5. - Causes of gas accumulations and dust suspensions in Indiana coal mines

Causes		Number of explosions
Insufficient or interrupted ventilation		7
Insufficient ventilation at face	6	
Insufficient ventilation, other than at face	1	
Open doors		1
Door left open	1	
Fans		1
Fan shut down at night	1	
Falls of roof and coal		6
Falls of roof released gas	4	
Falls of roof pushed gas out of abandoned workings	2	
Sealing of old workings		1
Dust raised into suspension		16
Shooting off solid (blown-out shot of black blasting powder)	15	
Ignition of black blasting powder	1	
		32

PREVENTION OF EXPLOSIONS IN INDIANA COAL MINES

In the reports of the various explosions occurring in Indiana, recommendations were made which it was believed at the time would prevent recurrence. These recommendations and the number of times they were made are given in table 6.

TABLE 6. - Recommendations for preventing explosions at time of occurrence

Recommendations	Times recommended
Better inspection	7
Better supervision	11
Undercutting coal	10
Dust control	15
Better ventilation	8
Permissible explosives	7
Incombustible stemming	8
Better placement of shots	8
Inspection of idle workings	2
Fire boss not to carry open light	3
Permissible flame safety lamps	2
Greater care in handling and distribution of powder	1
Closed lights	7
Examination of mine before allowing men to enter	2
Locked valves on pipes in seals	2
Keep fan running 24 hours	1

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Inspection.- Inspection for gas 6 or more hours before the working shift entered the mine, with the possibility that gas accumulated between the time of inspection and the time the shift entered, is believed to have been responsible for 1 of the major explosions with 37 fatalities.

Failure to inspect caving and squeezing territories during the shift was responsible for 2 major explosions, causing the loss of 51 and 28 lives, respectively.

The mining law of Indiana has recently been amended requiring continuous inspection for gas during the working shift whenever old workings are being approached or whenever places are squeezing and caving and gas is likely to be liberated.

Recommendation for better inspection for gas appears 7 times.

Supervision.- Recommendations for better supervision in connection with ventilation, handling of explosives, shooting, and rock-dusting appear 11 times.

Undercutting coal.- Recommendations for undercutting coal and for discontinuance of the dangerous practice of solid shooting appear 10 times. The importance of these recommendations is apparent when it is remembered that 111 explosions with 162 fatalities were caused by blown-out shots.

Dust control (rock-dusting, sprinkling, and water on the cutter-bars).- Control of the dust hazard by rock-dusting and watering was recommended 15 times. Although the State mining law was amended in 1927 making it mandatory for all dry and dusty coal mines to render the coal dust nonexplosive by the general use of rock-dust, little effective rock-dusting has been done in Indiana.

Since most explosions start in the active working sections of a mine, it is absolutely necessary that first consideration be given to these sections when rock-dust is applied if the maximum protection is to be obtained; it is not enough merely to rock-dust the haulage roads as is too often done. The efficacy of rock-dusting is generally conceded, but there is unfortunately a general lack of knowledge of how much and where the rock-dust should be applied in order to prevent the propagation of a coal-dust explosion.

Rock-dust should be applied to all open workings, including rooms, entries, and aircourses, as well as to haulage roads, in sufficient quantity that all dust passing through a 20-mesh sieve will contain at least 60 percent incombustible matter.

Open and abandoned sections of mines, in which it is impossible to use a rock-dust distributor, should be protected by suitable rock-dust barriers.

In addition to rock-dusting, to control the coal-dust hazard effectively the formation of dust should be allayed at its source by the application of

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water sprays to the mining-machine cutterbars, by wetting down the broken coal after shooting, and by sprinkling the roof, ribs, and floor for a distance of 50 feet back from the face before shooting.

Closed lights.- Closed lights were recommended 7 times. The use of closed lights became a controversial question between the operators and miners in Indiana shortly after they were introduced. At that time electric cap lamps were not always entirely satisfactory as the light was of low candle power and the batteries were heavy. In fact, it was because of the low candle-power and uncertain light given by these early lamps that the men derisively christened them "bug lights". In addition to the objection because of poor light, the men claimed that infrequent inspections by the companies might allow dangerous quantities of gas to accumulate where closed lights were used, whereas with open lights the accumulations would be ignited before they reached dangerous proportions.

As far as the first objection is concerned, electric cap lamps now on the market have been improved so much that they give a steady light of far greater average illumination than the open carbide lamp and the weight has been decreased until it is no longer a serious objection.

Regarding the second objection, it is obviously the duty of the mining company to furnish adequate ventilation and to make frequent inspections to prevent dangerous accumulations of gas at the working face.

Ventilation.- Recommendation for better ventilation appears 8 times and from an explosion hazard standpoint is perhaps the most important.

Ventilating fans at most Indiana mines are of adequate capacity, but they cannot deliver much air because the aircourses are restricted by falls. It is not unusual for as much as 80 percent of the air delivered by a fan to be lost between the fan and the face workings because of leaky doors and stoppings.

Permissible explosives.- Recommendation for the use of permissible explosives appears 7 times. Continued displacement by permissible explosives of black blasting powder in the mines of Indiana, together with undercutting of coal, without doubt has been the controlling factor in reducing the number of explosions from blown-out shots of black blasting powder.

Incombustible stemming.- It is common practice in Indiana to use drill cuttings or other fine coal for stemming with both permissible explosives and black blasting powder, despite the fact that coal-dust stemming increases the flame from a shot many times what it would be if incombustible stemming were used and thus greatly increases the explosion hazard. Recommendation for the use of incombustible stemming appears 8 times.

Better placement of shots.- Recommendation for better placement of shots following explosions in solid shooting mines appears 8 times, but as a matter of fact the same recommendation probably was made on many other unrecorded occasions.

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Miscellaneous.- Seven other recommendations made could have been included under inspection, supervision, or ventilation.

TYPES OF EXPLOSIVES USED

Table 7 shows the amount of black blasting powder and permissible explosives used in Indiana in 1919, 1923, 1927, 1931, and 1933.

TABLE 7. - Amount of explosives used in Indiana mines[1/]

Year	Black blasting powder, kegs	Permissible explosives, pounds
1919	817,875	279,057
1923	879,077	238,905
1927	404,928	327,551
1931	380,985	537,231
1933	354,867	227,257

1/ From information in the annual reports of the chief inspector of mines.

Although there is still much more black blasting powder than permissible explosives used in Indiana, a marked reduction has occurred since 1919 in the use of the former in favor of the latter.

FATALITIES AND MINE EXPLOSIONS

Table 8 shows the number of explosions, gas ignitions, minor explosions from blown-out shots, and the total fatalities for various periods up to 1933. It will be observed that the period 1914-23 had the greatest number of explosions, gas ignitions, and blown-out shot explosions; this was also the period of greatest development and production.

TABLE 8. - Number of explosions and fatalities from explosions in Indiana mines, 1878-1933

Years	Explosions	Gas ignitions	Blown-out shots	Fatalities
1878-1903[1/]	3	3	5	27
1904-1913	10	12	22	82
1914-1923	12	29	52	142
1924-1933	7	8	17	152

1/ 26 years.

Although the last period had fewer explosions, gas ignitions, and blown-out shot explosions than the previous one, it had the greatest number of fatalities from these causes due to 3 most disastrous explosions.

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The United States Bureau of Mines, through its Mine Safety Board, issues "decisions" on safety methods and practices. Decisions relating to explosion-prevention methods are as follows:

Decision 1:

The United States Bureau of Mines recommends:

1. In all coal mines the portable lamps for illumination be permissible, portable, electric mine lamps; and also
2. In places where fire damp or black damp is liable to be encountered, a permissible magnetically-locked flame safety lamp for gas detection, or equivalent permissible device, be supplied to at least one experienced employee in each such place; and
3. Any employee before being supplied with a permissible flame safety lamp be examined by a competent official of the mine to assure the man's ability to detect gas; and
4. All coal mines whether classed as nongassy or gassy in any part, be supplied with magnetically locked, permissible, flame safety lamps, properly maintained and in sufficient number for all inspection purposes.

Decision 2:

In the interests of safety the United States Bureau of Mines recommends that for blasting in coal mines, permissible explosives, fired electrically, be exclusively used; and that as an aid to blasting, all coal which is feasible to cut, should be cut or sheared.

Decision 4:

In the interest of safety, the United States Bureau of Mines recommends that auxiliary fans or blowers should not be used in coal mines as a substitute for methods of regular and continuous coursing of the air to every face of the mine.

Decision 5:

To prevent the propagation of mine explosion, the United States Bureau of Mines recommends rock-dusting all coal mines, except anthracite mines, in every part, whether in damp or dry condition. It also recommends that rock-dust barriers be used to sectionalize the mine as additional defense; but these should not be regarded as a substitute for generalized rock-dusting.

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Decision 6:

In the interest of safety, the United States Bureau of Mines recommends that in coal mines all entries, rooms, panels, or sections that cannot be kept well ventilated throughout or cannot be inspected regularly and thoroughly, or that are not being used for coursing the air, travel, haulage, or the extraction of coal, be sealed by strong fireproof stoppings.

Decision 7:

In the interest of safety, the United States Bureau of Mines recommends:

1. That the main intake and main return air currents in mines be in separate shafts, slopes, or drifts.
2. That the main intake shaft lining be of fireproof construction, and there be a minimum amount of inflammable material in or adjacent to the shaft.

Decision 9:

The United States Bureau of Mines recommends in coal mine ventilation practice the following specifications as to unit quantity and quality of air:

1. The quantity in cubic feet of pure intake air flowing per minute in any ventilating split shall be at least equal to 100 times the number of men in the split.
2. The quantity of air entering each unsealed place shall be at least 200 cubic feet per minute and as much more as may be necessary properly to dilute and carry away inflammable or harmful gases which may be present.
3. The air shall be made to circulate continuously to the face in every unsealed place into which an appreciable amount of methane enters.
4. The air in any unsealed place shall be considered unfit for men if it shall be found to contain less than 19 percent oxygen (dry basis), more than 1 percent carbon dioxide, or a harmful amount of poisonous gas.
5. If the air in any unsealed place, when sampled or tested in any part of that place not nearer than 4 feet from the face and 10 inches from the roof, shall be found to contain -
   (a) More than 1½ percent of inflammable gas, the place shall be considered to be in hazardous condition and require improved ventilation, and
   (b) If more than 2½ percent of inflammable gas is found, the place shall be considered dangerous, and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said place.

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6. If the air in the split which ventilates any group of workings contains more than 1½ percent of inflammable gas, these workings shall be considered to be in a dangerous condition and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said workings.

Decision 11:

In the interest of safety, the United States Bureau of Mines recommends that in coal mines, haulage and (or) hoisting be kept in intake air as far as possible.

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Decision 12:

The United States Bureau of Mines extending Mine Safety Decision 2, recommends that for blasting either coal or rock in coal mines, permissible* explosives or equivalent permissible device be used exclusively, and in addition recommends that in blasting**

1. Each charge shall be in a hole properly drilled and stemmed with incombustible material.

2. Each shot shall be fired separately by a permissible single-shot blasting unit, using an electric detonator or igniting equivalent of a kind specified by the Bureau for the particular permissible explosive or permissible blasting device.

3. Before and following each shot in gassy and slightly gassy coal mines, examination for gas shall be made with a permissible flame safety lamp or permissible equivalent*** and -

4. If more than 1½ percent of inflammable gas is found, in the quantity and by the method specified in Mine Safety Decision 9,**** the place shall be considered to be in a hazardous condition and before another shot is fired the gas shall be reduced by ventilation below the percentage and quantity specified in decision 9.

5. Each shot employing explosives shall be prepared and fired by or under the immediate supervision of a man having a state certificate as a mine examiner, fire boss, or foreman; and whenever conditions permit all other men than those authorized to prepare and fire shots shall be out of the mine when shot firing with explosives is being done.

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* Anything that has successfully passed scheduled tests and is officially approved by the United States Bureau of Mines is termed "permissible."

** Exception: This rule would not apply where shot firing is done electrically from the surface when all the men are out of the mine.

*** Mine Safety Decision 1 relative to permissible flame safety lamps or equivalent.

**** Decision 9, paragraph 5: If the air of any unsealed place when sampled or tested in any part of that place not nearer than 4 feet from the face and 10 inches from the roof shall be found to contain -

(a) More than 1½ percent of inflammable gas, the place shall be considered in a hazardous condition and require improved ventilation and -

(b) If more than 2½ percent of inflammable gas, the place shall be considered dangerous, and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said place.

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Decision 13:

The United States Bureau of Mines recommends that when electricity is used in coal mines rated as gassy,* or whenever in any mine the atmosphere may become gassy:

1. Electrical equipment shall be permissible,**
2. Nonpermissible electrical equipment*** shall be used only in pure intake air,****
3. Electrical power shall be cut off whenever the air in the workings is in a dangerous condition,***** due to inflammable gas.

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* Decision 3 classifies coal mines on the basis of the specific amounts of methane found in the mine atmosphere. See also, decision 9.

** Anything that has successfully passed scheduled tests and is officially approved by the U. S. Bureau of Mines is termed "permissible."

*** Including trolley wires, trailing cable connections other than through permissible junction boxes, and power lines (except armored rubber-covered cables which meet the specifications of the National Electrical Code.)

**** Decision 8 defines "pure intake air."

***** Decision 9 defines the proportion or amount of gas in a mine working which shall be considered dangerous.

Decision 15:

In the interest of safety in coal mining, the United States Bureau of Mines to lessen the coal-dust explosion hazard recommends that:

1. Machine coal cuttings be wet as the cutting is being done.
2. The coal face, and the working place 40 feet therefrom, shall be kept free of coal-dust by the use of water.
3. The top of loaded cars in the working place shall be wet.

Decision 16:

In the interest of safety in coal mining, the United States Bureau of Mines recommends that:

1. Machine cuttings be removed from the cut.
2. If the machine cuttings are of a character which would contribute to a dust explosion, they shall be sent out of the mine.

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Decision 17:

To lessen the formation and distribution of coal-dust in haulageways, the United States Bureau of Mines recommends that in bituminous and lignite coal mines:

1. The mine cars should be constructed and maintained dust-tight.
2. The coal should be so loaded that it will not shake off in haulage.
3. The cars and loads should be so sprayed as to prevent dust being distributed along the haulageways.

Decision 18:

In the interest of safety in coal mining, the United States Bureau of Mines recommends that:

1. The foreman regularly in charge of underground operations and also any person who, in the absence of the foreman, may be placed in temporary charge should each have a certificate of competency from the State to act as mine foreman.
2. The superintendent or person in responsible charge of the mine, to whom the mine foreman reports, should have a certificate of competency from the State which should be issued upon a showing of underground experience for a period of time as long as that required for a foreman's certificate and upon passing an examination including all technical questions asked in the examination required of foremen.*
3. These certificates should expire after some stated period of time, such as 5 years, and should be renewed only after the applicant has again passed the examination required by the State.

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* Requirements for foremen's certificates will cover this provision.

Decision 20:

In the interest of safety in underground mining, the United States Bureau of Mines recommends that:

While driving tunnels or drifts and sinking or raising shafts or slopes, and also in their operation, there should be an adequate ventilating current wherever men work or travel.

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CONCLUSIONS

The principal underlying causes of mine explosions in Indiana have been insufficient or interrupted ventilation and the reckless use of black blasting powder. The chief causes of ignitions of gas or dust have been open lights, blown-out shots of black blasting powder, and explosives.

Prevention of explosions depends largely upon adequate ventilation and inspection, thorough rock-dusting and the wetting of coal dust at the face to prevent its dissemination throughout the mine, use of permissible explosives and equipment, and last, but by no means least, upon proper supervision to insure that the foregoing fundamental requirements are actually utilized at all times.

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